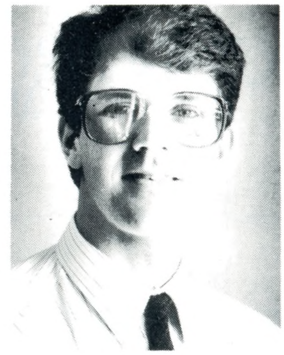
The Geodesy Corner

CONTROL SURVEYS - WHO NEEDS THEM?



BY JAMES FERGUSON

I'm in the process of building a model which depicts a typical control network along a hydroelectric mapping corridor. The scene shows a series of mountain ranges, a couple of rivers, and suitable flora to make it interesting. The model "user" is able to select and "monument" suitable control sites, set-up a survey instrument (GPS in this case), and design a survey network to "control" the area that is to be potentially mapped. The entire scene is fictitious, but it brought to my mind several questions that might be asked when discussing the term "control survey"; thus leading us to the Geodesy Corner topic for this issue.

The above scenario is but one of a large number of applications of control surveys. If we approach the subject of control surveys intending to discover what is actually produced from such a survey, and for what purpose, then we can more ably answer the why's, where's and how's of control surveying.

In the fields of land surveying, mapping, geographical studies, geological surveys, and geophysical surveys to name just a few, we often need a basis on which to hinge future survey requirements. This basis may be a single point providing reliable height information for a water project, or it may be a complex framework of survey stations that provide precise horizontal positions for a Geographic Information System. It may also take the form of a loosely defined system of natural features, recognizable from the ground or from photographs. Whatever the basis, it is clear that the products of each of these surveys are different in nature, and they are also different in purpose. This notion of difference of purpose is fundamental in understanding the scope of control surveys.

Ask the question of a land, or geodetic surveyor as to what constitutes purposes for a control survey, and they might present you with a list of some of the major areas:

Control for Topographic Mapping;
Construction Survey Control;
Hydrographic Survey Control;
Mining Survey Control;
Photogrammetric Survey Control;
Dam Deformation Studies;
Crustal Plate Motion Studies;
Hydrometric Survey Control;
Control for Geographic Information Systems;
along with a host of others.

We see there is a great diversity in the above survey control needs, and the end product of surveys for each purpose is different. To gain a broader perspective of product needs for control surveys, I've chosen the following three scenarios from the above list for closer examination:

1) Control for Topographic Mapping
2) Hydrometric Survey Control
3) Control for Geographic Information Systems

By answering the following questions for each scenario, we can see the similarities and differences between them.

* What is the purpose of the control survey, or why is it needed?
* Is there a specific methodology that is generally used for this type of survey?
* What accuracies are needed for the survey, and
* What is the end product of the survey, or what does the client want?

1) Control For Topographic Mapping

Topographic mapping has traditionally involved the acquisition of field data in order to portray the relief of an area. The topographic data can be used for making maps, digital terrain models, and digital elevation models among other things. Various methods are used to acquire the essential vertical and horizontal information of required physical features. The control survey comes in at the stage where all the feature data is needed in a homogeneous system. The purpose of the control survey therefore, is to connect a large quantity of data to a more structured, stable survey framework. Various survey methods are used to accomplish a survey of this type, conventional and satellite techniques among them, and in general, topographic survey control requires accuracies of a relatively low order compared to other more rigid surveys.

The question still remains as to the end product of a topographic control survey. As with most surveys, both horizontal and vertical data is required to establish a useful control framework for topographic purposes. If the survey data is to be used in conjunction with adjoining data, then there must be a common link between both data sets. This problem is overcome by hooking into a second, previously established system of control and using it as common ground. These existing systems of control are familiar to use as the NAD27 or NAD83 survey datums. We are then able to produce functional coordinate information for our topographic control survey, and finally, for all the acquired topographic data. Deliverables to the client may include northings, eastings and elevations for each point or topographic feature.

2) Hydrometric Survey Control

Hydrometric surveying is a specialized field involving the study of the characteristics of water. These studies include flow velocities, flow volumes and levels, and rely on a system of monitor stations whose positions are

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known to a high degree of accuracy. The water monitor stations are located near the edges of lakes, or along the banks of rivers, and must provide hydrometric information to meet precise requirements. Information exchanged, or utilized between adjacent stations must be reliable in terms of its' relationship to the neighbour station. Therefore, a stable survey base is required to ensure that any calculations performed on data between monitor stations are as accurate as possible. In the past, conventional survey techniques have been used almost exclusively, since no other methods provided the accuracy and precision required. With the advent of the Global Positioning Systems (GPS), it is now possible to achieve similar results with relatively more ease. But what are the results, or product, we need for the survey control base.

Since hydrometric surveys involve data for the computation of horizontal and vertical information, it is necessary to provide each monitor station with a reliable position in both horizontal and vertical components. Based on experience, the most important of the two is the vertical component. In order to provide accurate vertical positions using, say GPS, it is necessary to dig into our bag of tools required for this type of survey. We will have to address the problems of ellipsoids and datums, finding suitable starting points, or benchmarks, and calculating the undulation of the geoid for the monitor stations. As with the topographic control survey, the horizontal control fabric must be tied to existing control surrounding the new project area. The results of the new survey will then be available in the same system as the local area.

For this type of survey, we will need to provide the client with results which have relative precisions on the ten parts per million level (10 ppm), or an error of no more than one centimetre over a one kilometre length. This precision is often classified as surveying to "first order" (or better) standards. Depending on the variety of uses for the survey control results, the final product to the client will be a list of monitor stations with their respective coordinate values. Horizontal values may be delivered as latitudes and longitudes, or northings and eastings in the form of Universal Transverse Mercator (UTM) coordinates.

3) Control for Geographic Information Systems (GIS)

Our last survey control scenario is one of today's most popular and widely discussed survey topics. Still, most of the discussion and expertise centres on the GIS itself, not on the basis, or framework used to coordinate the entire system. Thus, there is currently a lack of public knowledge in the area "controlling" a GIS database.

There are many different uses envisioned for GIS, and the populace has only begun to discover its almost limitless possibilities. There is GIS for forest inventory, road definition, public utilities coordination, legal survey fabrics, vehicle location, assessment roles, and hundreds of other uses. Although these applications do require similar bases for their integration, some need a control product that is more precise.

Controlling a GIS from a surveyor's point of view can be done using traditional survey methods, GPS, or a combination of the two. Projects done in southern Ontario in the last couple of years have proven the value of the integration of these two types of survey methodologies. And, of course, each method of survey can be done to meet the specific needs of the GIS system. A forest inventory for example may need a base accurate to a few metres, whereas a GIS which monitors the laying of underground cables, may need to be accurate to within a few centimetres. Assessment roles may require a control base somewhere in between these latter two accuracies. When looking at GIS control accuracy needs, one should be sure that the survey meet the needs of the most exacting user.

The control fabric for GIS is generally a system of physical monuments, placed in a grid pattern over the project area. Since most GIS work is done in populated areas, it is usually not a difficult task to locate existing control stations to connect to the new system. Depending on the requirements and specifications for the control fabric, horizontal control can be obtained from a few existing stations surrounding the area, and vertical values can be brought in from local benchmarks. Ensure that you understand all municipal, provincial and federal requirements regarding the method of survey you are using.

The end product of the GIS framework must be a coordinate system useful to all its users. Horizontal data is a must, and vertical information is required in many GIS applications. Again we would deliver either geographical coordinates for each framework station, or mapping plane northings and eastings. Vertical values will be referenced to benchmarks in the local vertical datum. All of these coordinates are delivered in both hard copy and digital forms.

In each of the above scenarios, the end control product should carry with it a measure of reliability. This reliability is normally obtained through an adjustment of the data, and an analysis process. Adjustments will be the subject of an upcoming Geodesy Corner.

Please let me know your comments and suggestions (c/o 6 - 1050 Baxter Road, Ottawa, Ontario, K2C 3P1). Next time in the Geodesy Corner "What Does the Global Positioning System (GPS) Give us"?

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